Balancing, Modernization & Revamp of Ammonia Plant

Presented By:
Jaffar Abbas
Sr. Manager
Purpose

Synopsis of activities carried out for Ammonia Plant Balancing, Modernization & Revamp (BMR) at Fauji Fertilizer Bin Qasim Limited Pakistan - FFBL
Sequence

- Introduction of FFBL
- Ammonia Plant BMR
Fauji Group

FFC Fertilizer
FFBL Fertilizer
FCCL Cement
FKPCL Power
Fauji Oil Terminal
Gas E&P
Fauji Corn Food
Fauji Cereals Food
Fauji Sugar Mills
Foundation Gas
Wind Power
Share Holding in FFBL

- Fauji Fertilizer Co.: 51%
- Fauji Foundation: 17%
- Others: 32%
Our Brand

Market Share 51%

Market Share 66%
Salient Points

- Company established in Nov 1993
- Complex consists of Ammonia, Urea, DAP and Utilities plants
- Commercial Production achieved in Jan 2000
- Total project cost US$ 469 Million
- Sole producer of Granular Urea & DAP in Pakistan
- Listed among top-25 companies in Karachi Stock Exchange
## Revamps

<table>
<thead>
<tr>
<th>Plant</th>
<th>Study by</th>
<th>Amount</th>
<th>Capacity Increased</th>
<th>Highest Achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonia - BMR</td>
<td>Haldor Topsoe</td>
<td>€ 46 M</td>
<td>122%</td>
<td>130%</td>
</tr>
<tr>
<td>DAP - Revamp</td>
<td>Jacobs Engg</td>
<td>$ 28 M</td>
<td>150%</td>
<td>179%</td>
</tr>
<tr>
<td>Urea - Siphon Jet Trays</td>
<td>Stamicarbon</td>
<td>$ 120K</td>
<td>108%</td>
<td>120%</td>
</tr>
</tbody>
</table>
Other Major Projects

- JV Project in Morocco producing 375,000 MT as P$_2$O$_5$ - $230$M
- Investment in Wind Power Project 100 MW - $46$ M
- Investment in Cement Plant - $4.7$ M
- Organizational Business Transformation by implementing SAP with Big Bang approach & Lotus Applications - $3.4$ M
SAP Modular Structure - Overview

**Legends:**
- S&D  Sales & Distribution
- MM  Material Mgt
- PP  Product Planning
- QM  Quality Mgt
- PM  Plant Maintenance
- BI  Business Intelligence
- HCM  Human Capital Mgt
- FI  Financial Account
- CO  Controlling
- IM  Investment Mgt
- PS  Project System
- DM  Documents Mgt
- WF  Workflows
Integrated Management System (IMS)

- Quality Management System (ISO-9001-2008)
- Environment Management System (ISO-14001-2004)
- Occupational Health & Safety (OHSAS-18001-2007)
Ammonia BMR
Ammonia Plant

**Design:**
Bechtel, USA, Single Front-end and two parallel Back-End Loops

**Plant History:**
- Vintage : 1965
- Shutdown in USA : 1992
- Relocated : 1996
- Re-commissioned : 1998
- Revamped : 2007
Bottle Necks

- Old Technology
- Plant & Equipment physical health
- Frequent plant trips, equipment failure and leakages
- Capacity limitation due to change in site conditions and Feed Stock
- Dual back end loops and High energy index
- Non availability of Hydrogen Recovery Unit
Key Consideration For BMR

1. Inherent reliability issues
2. Name plate capacity not achieved due to capacity limitations
3. High energy index
4. Loosing, time dependent subsidy on Feed Gas
5. Accumulation of financial charges due to delay in commissioning and inconsistent production
6. BMR more viable than a new plant
7. Best technical resource available within FFBL
8. Forecasted market dynamics favorable for investment and future plans
Objectives

- Improve
  - Safety and Reliability
    - Productivity
    - Energy Efficiency
- Address demand of Fertilizer in Pakistan
- Improve Profit margin against limited duration of subsidy on Feed Stock
Implementation Plan

- NG Compressor
- Primary Reformer
- Secondary Reformer
- W / H Boiler
- Shift Conversion
- Catalyst Tubes
- Air Compressor
- H₂ Recovery
- Ammonia Synthesis
- Ammonia Refrigeration
- Methanator
- CO₂ Removal
- Ammonia Turbines
- S-200 Baskets
- Syn Comp Mod
- TA-06
- TA-07

Misc. Pumps, Heat exchangers, Vessels & Control valves
Project Monitoring

PROGRESS AS ON (13-02-07)
Planned: 96%
Actual: 93%

Plan revised after approval of 1570 MTPD case

13-Feb-2007
Stationary Equipment - Scope

- Primary and Secondary Reformers
- Waste Heat Boilers in heat recovery steam generation
- Absorber and Regenerators in CO$_2$ removal
- Ammonia Convertors
- Hydrogen Recovery Unit
- Ammonia Recovery Unit
- Heat Exchangers, Piping & Structure
## Recommended Modifications Executed

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Modification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Reformer F-101</td>
<td>Issues in Convection and Radiant sections addressed</td>
</tr>
<tr>
<td></td>
<td>All 432 Catalyst tubes replaced with high efficiency thin walled Micro Alloy tubes</td>
</tr>
<tr>
<td></td>
<td>Inlet / outlet headers replaced with improved material</td>
</tr>
</tbody>
</table>

**Old Thick Walled**
- Ø88 +0 - 0.8
- MSW 0.312”
- MSW 7.92
- 14.5 MW

**New Thin Walled**
- Ø4.216” + 0.045”
- Ø107.09” + 1.14
- Ø3.465” + 0 - 1/32”
- Ø88 +0 - 0.8
- Ø107.6 +2 - 0
- Ø78.6 +0 - 2.4
<table>
<thead>
<tr>
<th>Equipment</th>
<th>Modification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secondary Reformer C-102</td>
<td>Burner replaced with improved design Refractory replaced to address hot zones due to cracks in refractory</td>
</tr>
</tbody>
</table>
## Recommended Modifications Executed

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Modification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste Heat Boiler E-101 A/ B</td>
<td>Replaced due to:</td>
</tr>
<tr>
<td></td>
<td>1. Capacity Limitations</td>
</tr>
<tr>
<td></td>
<td>2. Reliability issues</td>
</tr>
<tr>
<td></td>
<td>• Aging</td>
</tr>
<tr>
<td></td>
<td>• Performance limitations</td>
</tr>
</tbody>
</table>
Waste Heat Boilers - Replacement

Salient Points

- Baking of exiting nozzle joint for removal of induced Hydrogen
- Smooth alignment of HEX with allied equipment & piping

Achievement:

Job executed as per plan and without any surprise
Rigging Structure

HOT END Foundation

COLD END Foundation

N

E-101 A

E-101 B

PULLING Action
HEX REMOVAL

Old

New

Cont.....
# Recommended Modifications Executed

<table>
<thead>
<tr>
<th>Equipment</th>
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</tr>
</thead>
<tbody>
<tr>
<td>CO2 Absorber &amp; Regenerators</td>
<td>• Engineering by UOP</td>
</tr>
<tr>
<td></td>
<td>• All Sieve trays removed and Packed Bed System installed</td>
</tr>
<tr>
<td></td>
<td>• Lo-Heat system, Flash vessel with Ejector system and Condensate re-boiler installed</td>
</tr>
</tbody>
</table>
CO2 Removal System

- CO₂ Absorber: C - 208
- Carbonate Regenerators: C - 203 A/B
**CO$_2$ Removal System**

**Bottle Necks**

- Production limitation due to high $\Delta P$ at the Absorber 1.2 Kg
- High energy consumption/ton CO$_2$
- Damage of trays / Cumbersome maintenance
- Corrosion in weld seams due to solution channeling
**CO₂ Removal System**

**Modifications requiring PWHT:**

- Gas Injection Support Plates
- Bed Limiter clips welded with vessel
- Process Gas Inlet Nozzle modified from 14” to 20”
- Additional Man ways
- Additional unloading Nozzles
- New packing discharge nozzles at the bottom each bed
- Modify rich solution inlet nozzles from 14” to 20”
- New inlet steam nozzle
- Modify steam injection nozzle from 8” to 12”
CO₂ Absorber Revamp Scheme

1. Removal of existing trays
2. Modification of existing nozzles
3. Fixing of bulk heads & insulation
4. Installation of heaters & burners
5. PWHT of bands sequentially from top
6. Removal of all PWHT arrangements
7. Fixing of gas Injection support plates
8. Loading of IMTP packing beds
9. Fixing of liquid distributors
10. Fixing of bottom bed limiter
1. Removal of existing trays.
2. Modification of existing nozzles
3. Fixing of bulk heads & insulation
4. Installation of heaters
5. Post weld heat treatment of bands one-by-one starting from top
6. Removal of all PWHT arrangements
7. Fixing of gas Injection support plates
8. Loading of IMTP packing beds
9. Fixing of liquid distributors
Rigging Plan Holding Regenerators During PWHT

Loading Capacity = 25 Tons.
**CO₂ Removal System**

**Post BMR Achievements:**

- Absorber $\Delta P$ reduced from 1.2 to 0.2 kg
- Energy consumption reduced by 10%
- No further deterioration in weld seams
- Easy to maintain Packed bed installed
### Recommended Modifications Executed

<table>
<thead>
<tr>
<th>Equipment</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Ammonia Convertors</td>
<td>Convertors baskets replaced with improved S-200 design</td>
</tr>
<tr>
<td>C-301 A/B</td>
<td></td>
</tr>
</tbody>
</table>
Ammonia Convertors

Replacement Obligation

- High DP in Existing TVA Basket
- Temperature limitation
- Capacity Limitation for Revamp Case
- Reliability Enhancement

Solution

- TVA basket replaced with improved design Radial flow S-200 basket
- Convertors Pressure Drop reduced from 18 to 2 Kg/ cm²
- Ammonia conversion improved from 12 to 14%
Sequence of Installation

**LEGENDS:**
1. 1\textsuperscript{st} Cat. Bed
2. Inter Bed HEX
3. 2\textsuperscript{nd} Cat. Bed
4. Lower HEX
5. Pressure Shell

**SEQUENCE**

- Installation of empty basket
- Removal of first bed / Inter-bed HEX
- Loading of Catalyst in second bed
- Reinstallation of first bed/Inter bed HEX
catalyst loading and Box up
Rigging of S-200 Basket
# Recommended Modifications Executed

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<th>Equipment</th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Ammonia Recovery Unit</strong></td>
<td>• Modified to recover enhanced capacity of Purge Gas</td>
</tr>
<tr>
<td></td>
<td>• 33 MT Ammonia being recovered</td>
</tr>
<tr>
<td><strong>Hydrogen Recovery Unit</strong></td>
<td>▪ 84 MT Unit installed to recover Hydrogen by 85%</td>
</tr>
<tr>
<td></td>
<td>▪ Recovered gas recycled to 1st stage of Synthesis Compressor</td>
</tr>
<tr>
<td></td>
<td>▪ Non-permeate utilized as a fuel in Aux Boiler</td>
</tr>
</tbody>
</table>
Turbo Machines - Scope

- Air Booster Compressor K-1001A/B
- Air Compressors K-101A/B
- NG Booster Compressor K-1003
- Semi-Lean Pumps G-201A/B/C
- Ammonia Refrigerant Compressors K-305A/B
- Synthesis Compressors K-306A/B
- Cooling Water Pump QP-1012
Recommended Modifications Executed

<table>
<thead>
<tr>
<th>Machine</th>
<th>Modification</th>
</tr>
</thead>
<tbody>
<tr>
<td>NG Booster Compressor K-1003</td>
<td>• New compressor installed to operate at lower suction Pressure (14.28Kg/cm²) and address fluctuation in Natural Gas supply pressure</td>
</tr>
</tbody>
</table>
### Recommended Modifications Executed

<table>
<thead>
<tr>
<th>Machine</th>
<th>Modification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Booster Compressors K-1001A/B</td>
<td>• New Compressors installed at suction of both Air Compressors K-101A/B to address additional air flow requirement.</td>
</tr>
<tr>
<td>Machine</td>
<td>Modification</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Lean solution Pumps G-201 A/B/C</td>
<td>• New Hydraulic Pumps with modified differential head from 800 to 850 FT</td>
</tr>
<tr>
<td></td>
<td>• New motor installed to address reliability and additional power requirement of new pump</td>
</tr>
</tbody>
</table>
## Recommended Modifications Executed

<table>
<thead>
<tr>
<th>Equipment</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Ammonia Refrigerant Compressors K/KT-305A/B</td>
<td>• Key flaring problem of HP to LP rotor addressed by two key improved material shaft rotors</td>
</tr>
<tr>
<td></td>
<td>• Turbine new rotors installed with improved material addressing reliability of machines</td>
</tr>
</tbody>
</table>

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![Old](image1.jpg) ![Modified](image2.jpg)
<table>
<thead>
<tr>
<th>Equipment</th>
<th>Modification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synthesis Gas Compressors K-306A/B</td>
<td>• HPC bundle in both Compressors modified to overcome limitation of recycle stage of HPC</td>
</tr>
<tr>
<td>Cooling Water Pump QP-1012</td>
<td>• New pump installed to cater Cooling Water additional requirement for BMR</td>
</tr>
</tbody>
</table>
Catalyst

Revamp results achieved without change in specifications of Catalysts in use

- Hydrogenation TK-550
- Sulphur Absorption HTZ-5
- Steam Reforming R-67-7H
- Secondary Reforming TRHS-2-7H
- Co Conversion-high Temp SK-201-2
- Co Conversion-low Temp LK-821-2
- Methination PK-5
- Ammonia Synthesis KM / KMR
Safe execution without “Lost Time Injury” or major incident

Completion of 100% scope within targeted 91 days

Capacity factor improved from 80 -130%

Energy Index improved from 11.4 to 9.0 Gcal/MT

Unique scope carried out for modifications in Benfield Towers for the first time in Pakistan

High reliability achieved in rotating equipment

Service factor improved from average 84% pre BMR to 97% post BMR
Challenges Faced

- Primary reformer Catalyst tube outlet flange dissimilar weld joint internal grooving due to condensation
  - All Flanges replaced with Inconnel material
- Deep cracks in HTSC catalyst unloading nozzle
  - Extensive repair carried out
- Crane capacity limitations during removal of old convertor basket
  - Crane was deployed wrt empty basket weight. Due to failure of Catalyst extracting vacuum pump, Crane capacity enhanced in-situ from 65 to 85 Tons to remove basket along with catalyst load
Challenges Faced

- Ammonia compressor coupling got damaged due to liquid ammonia carry over in LPC through anti-surge line, thus overloading the machine
  - Coupling (Dry) replaced
  - SOP revised
Challenges Faced

- Deteriorated condition discovered in Air Compressors LP rotors
  - One replaced
  - Protective coating applied on both rotors

- Newly fabricated exchanger Ammonia condenser rejected during Inspection
  - Existing HEX installed after modifications
Key Success Factors

- Management commitment and support
- Dedicated Project team of best resource
- Timely deliverables and strong backup from all stakeholders
- Thorough planning and execution
- No major surprise encountered
- Close monitoring of all phases
- Comprehensive training of staff for smooth start-up of Plant with new processes / equipment
Thank you
# Recommended Modifications Executed

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Modification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exchangers / Piping / Structure</td>
<td>- 16 Exchangers replaced, 09 newly installed</td>
</tr>
<tr>
<td></td>
<td>- 35000 Dia inch Piping installed</td>
</tr>
<tr>
<td></td>
<td>- 500 Metric Tons structure installed</td>
</tr>
</tbody>
</table>